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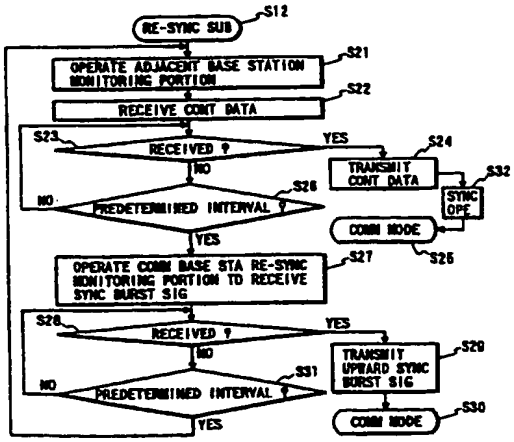
(54) **Mobile radio re-synchronizing procedure; communication handover**

(57) A mobile radio (B, Figs.1A,1B) in communication with a first base station (A1) on a TDMA/TDD traffic channel performs a re-synchronizing subroutine in response to detecting that the level of the signal from the base station is below a first reference or the bit error rate is above a second reference. In a first part of the subroutine, the mobile tunes to the control channel of an adjacent second base station (A2) and performs a synchronizing operation with that station in response to receiving control data therefrom, whereby communication handover to the adjacent base station is effected. If the mobile does not receive control data from the adjacent base station within a predetermined interval, it performs a second part of the subroutine by monitoring for a sync burst signal transmitted from the first base station (A1) when it cannot receive the signal from the mobile during the communication on the traffic channel. If the mobile receives the sync burst, it transmits a sync burst to the first base for re-establishing the communication through the first base. If the mobile fails to receive the sync burst during a predetermined interval, the subroutine returns to the first part, the first and second parts being alternatingly repeated until the mobile establishes communication through the second base or re-establishes communication through the first base. In an alternative subroutine, the mobile first attempts to re-synchronize to the first base station and then attempts to synchronize to the second base station.

FIG. 6B



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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FIG. 1A

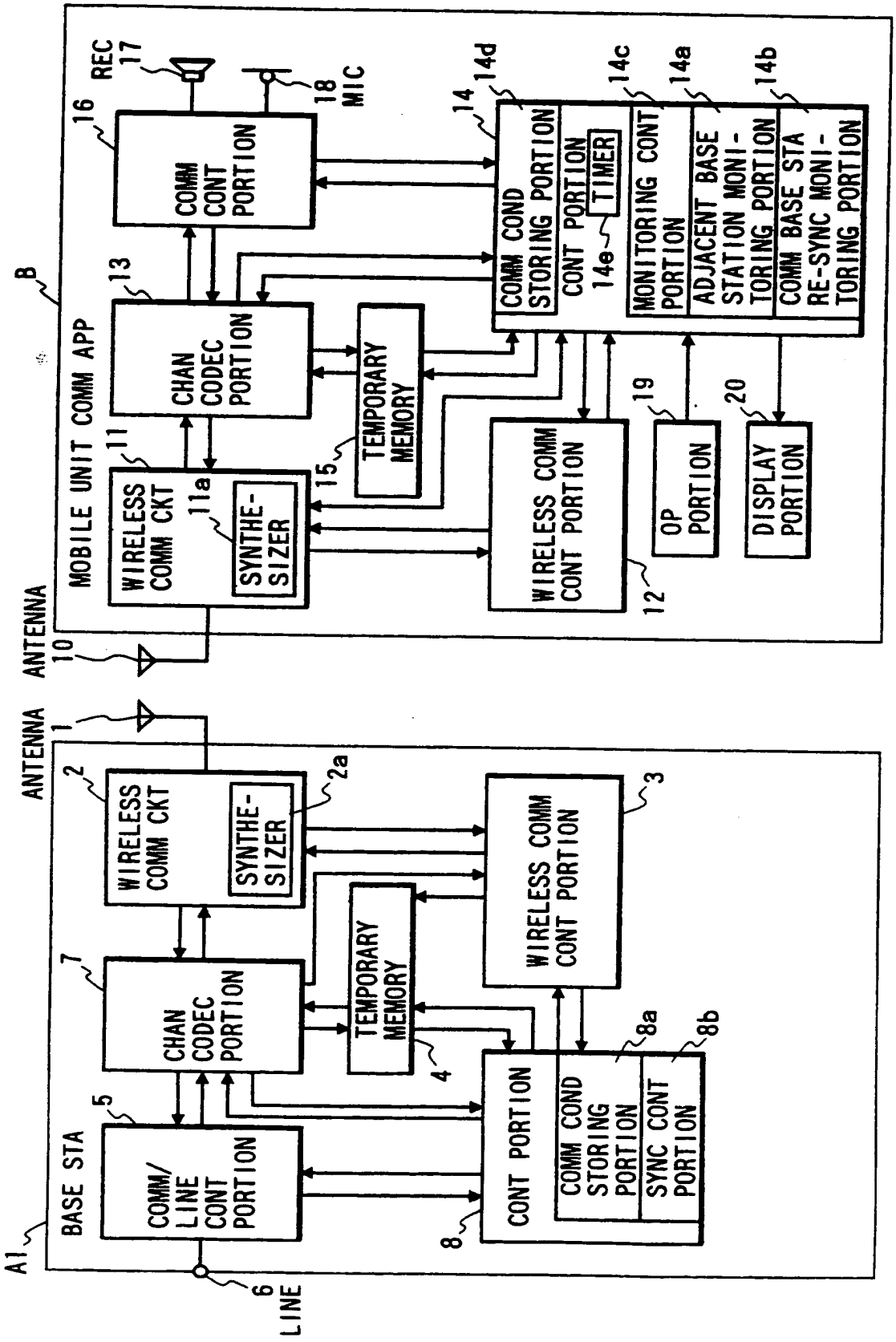

A1
BASE STA
ANTENNA
1
WIRELESS COMM CKT
2
SYNTHE-SIZER
2a
WIRELESS COMM CONT PORTION
3
CHAN CODEC PORTION
7
TEMPORARY MEMORY
4
COMM/ LINE CONT PORTION
5
CONT PORTION
8
COMM COND STORING PORTION
8a
SYNC CONT PORTION
8b
LINE
6
B
MOBILE UNIT COMM APP
ANTENNA
10
WIRELESS COMM CKT
11
SYNTHE-SIZER
11a
CHAN CODEC PORTION
13
TEMPORARY MEMORY
15
COMM CONT PORTION
16
REC
17
MIC
18
WIRELESS COMM CONT PORTION
12
COMM COND STORING PORTION
14
14d
CONT PORTION
14e
TIMER
MONITORING CONT PORTION
14c
ADJACENT BASE STATION MONI-TORING PORTION
14a
COMM BASE STA RE-SYNC MONI-TORING PORTION
14b
OP PORTION
19
DISPLAY PORTION
20

FIG. 1B

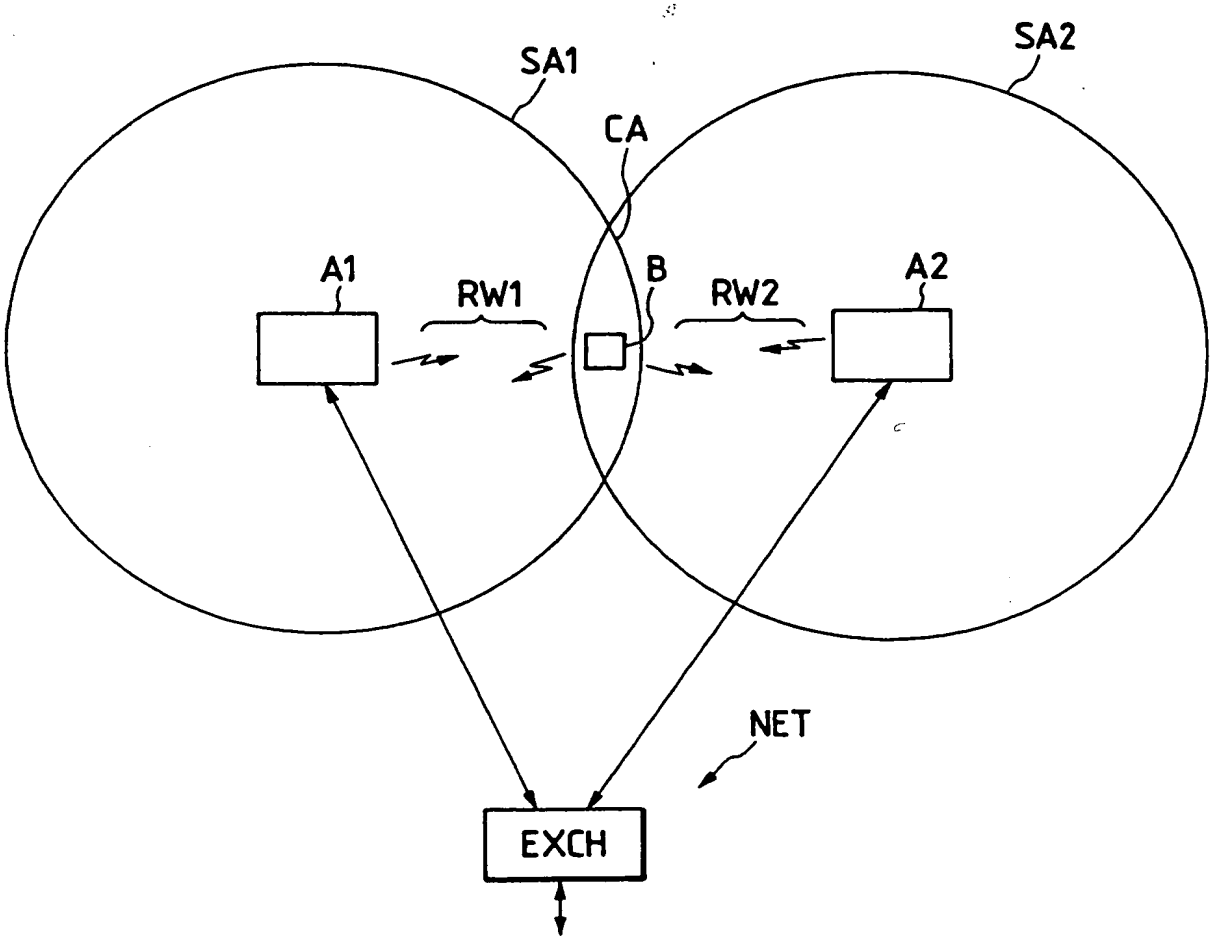


FIG. 2

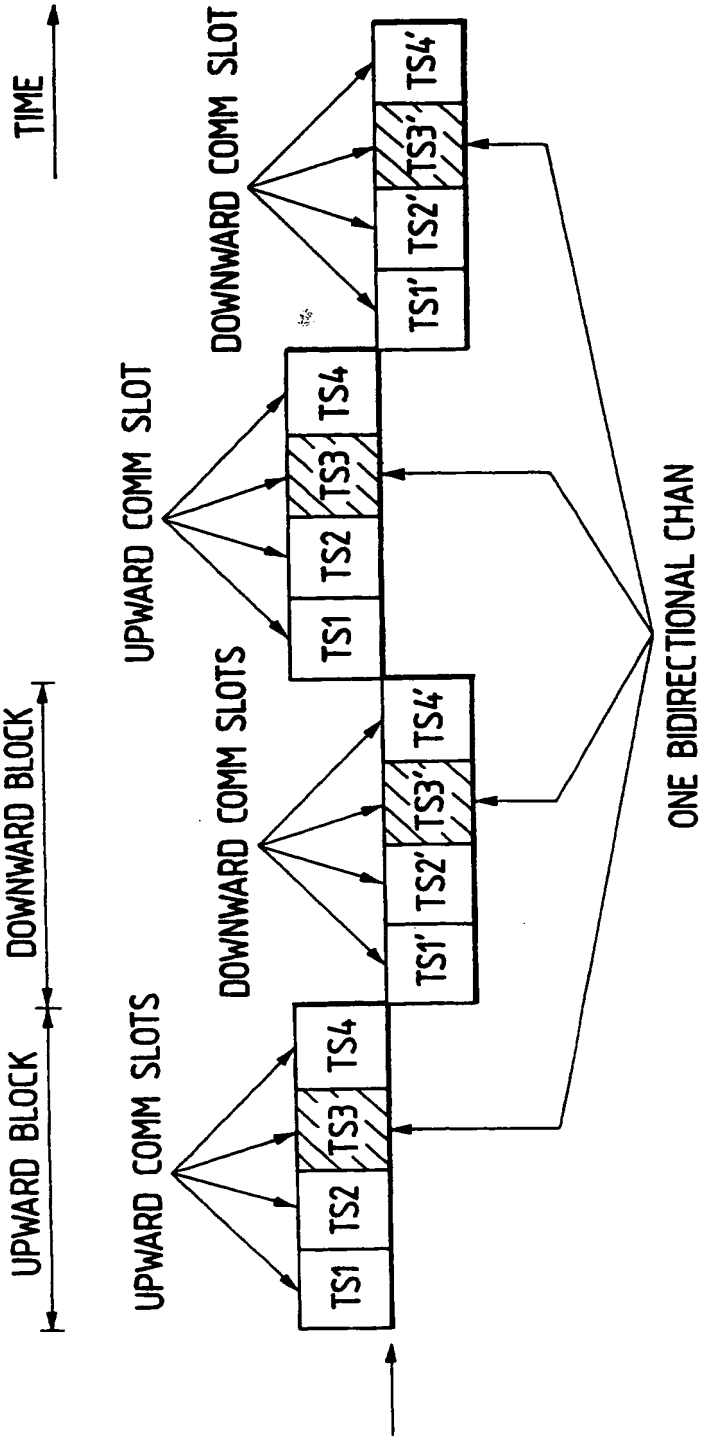

TIME
UPWARD BLOCK
DOWNWARD BLOCK
UPWARD COMM SLOTS
TS1
TS2
TS3
TS4
DOWNWARD COMM SLOTS
TS1'
TS2'
TS3'
TS4'
UPWARD COMM SLOT
DOWNWARD COMM SLOT
ONE BIDIRECTIONAL CHAN

FIG. 3

COMM BURST IN COMM CHAN

PR	UW	CONT DATA	USER DATA (SOUND SIG · DATA)	CRC

CONT DATA BURST IN CONT CHAN

PR	UW	BASE STA ID	MOBILE UNIT ID	CONT DATA	CRC

SYNC BURST IN COMM CHAN

PR	UW	MOBILE UNIT ID	SYNC BURST FIXED PATTERN	CRC

PR : PREAMBLE
UW : UNIQUE WARD
CRC : CRC CHECK BIT

FIG. 4

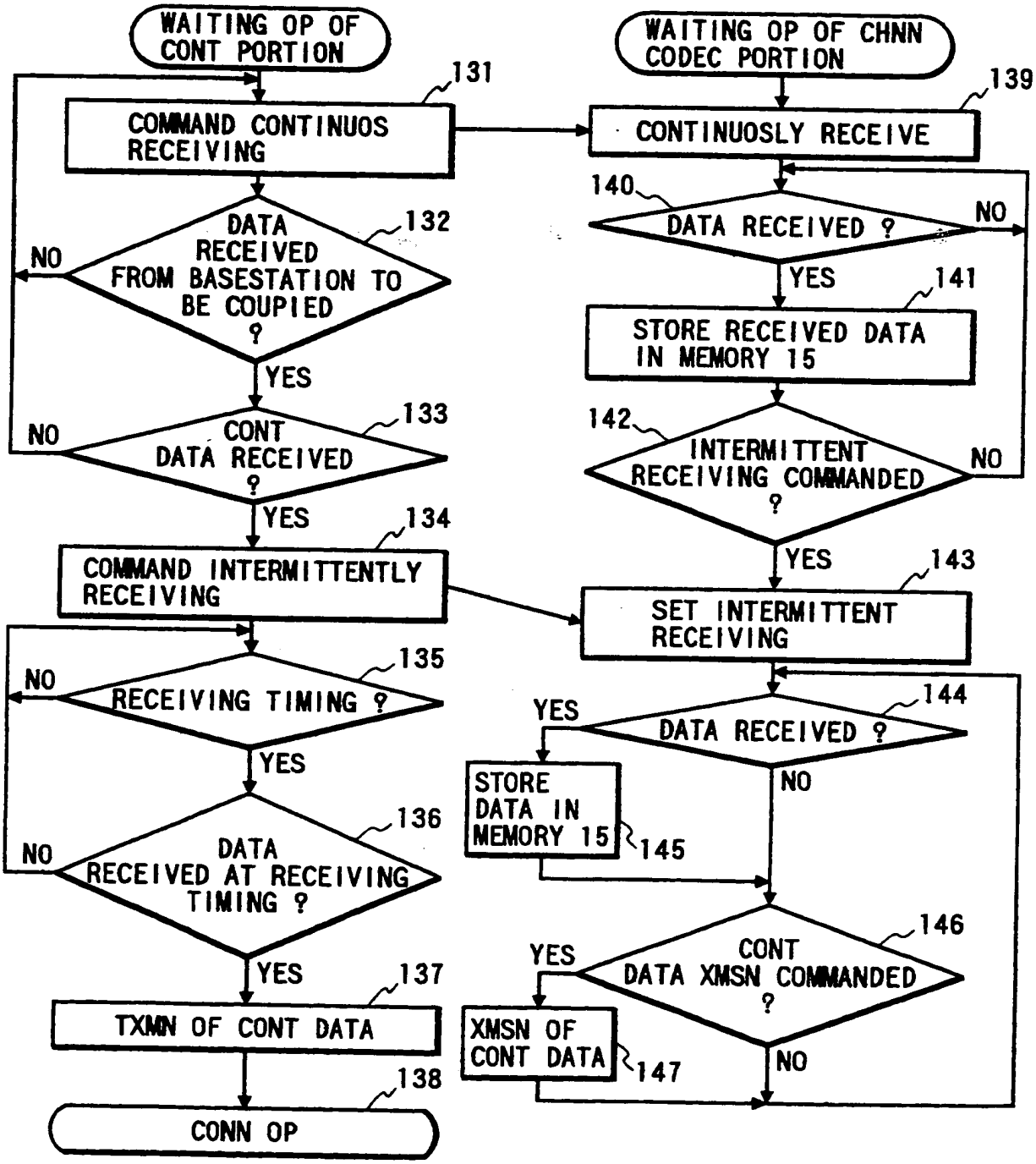

WAITING OP OF CONT PORTION
131
COMMAND CONTINUOS RECEIVING
132
DATA RECEIVED FROM BASESTATION TO BE COUPIED ?
NO
YES
133
CONT DATA RECEIVED ?
NO
YES
134
COMMAND INTERMITTENTLY RECEIVING
135
RECEIVING TIMING ?
NO
YES
136
DATA RECEIVED AT RECEIVING TIMING ?
NO
YES
137
TXMN OF CONT DATA
138
CONN OP
WAITING OP OF CHNN CODEC PORTION
139
CONTINUOSLY RECEIVE
140
DATA RECEIVED ?
NO
YES
141
STORE RECEIVED DATA IN MEMORY 15
142
INTERMITTENT RECEIVING COMMANDED ?
NO
YES
143
SET INTERMITTENT RECEIVING
144
DATA RECEIVED ?
YES
NO
STORE DATA IN MEMORY 15
145
146
CONT DATA XMSN COMMANDED ?
YES
NO
XMSN OF CONT DATA
147

FIG. 5

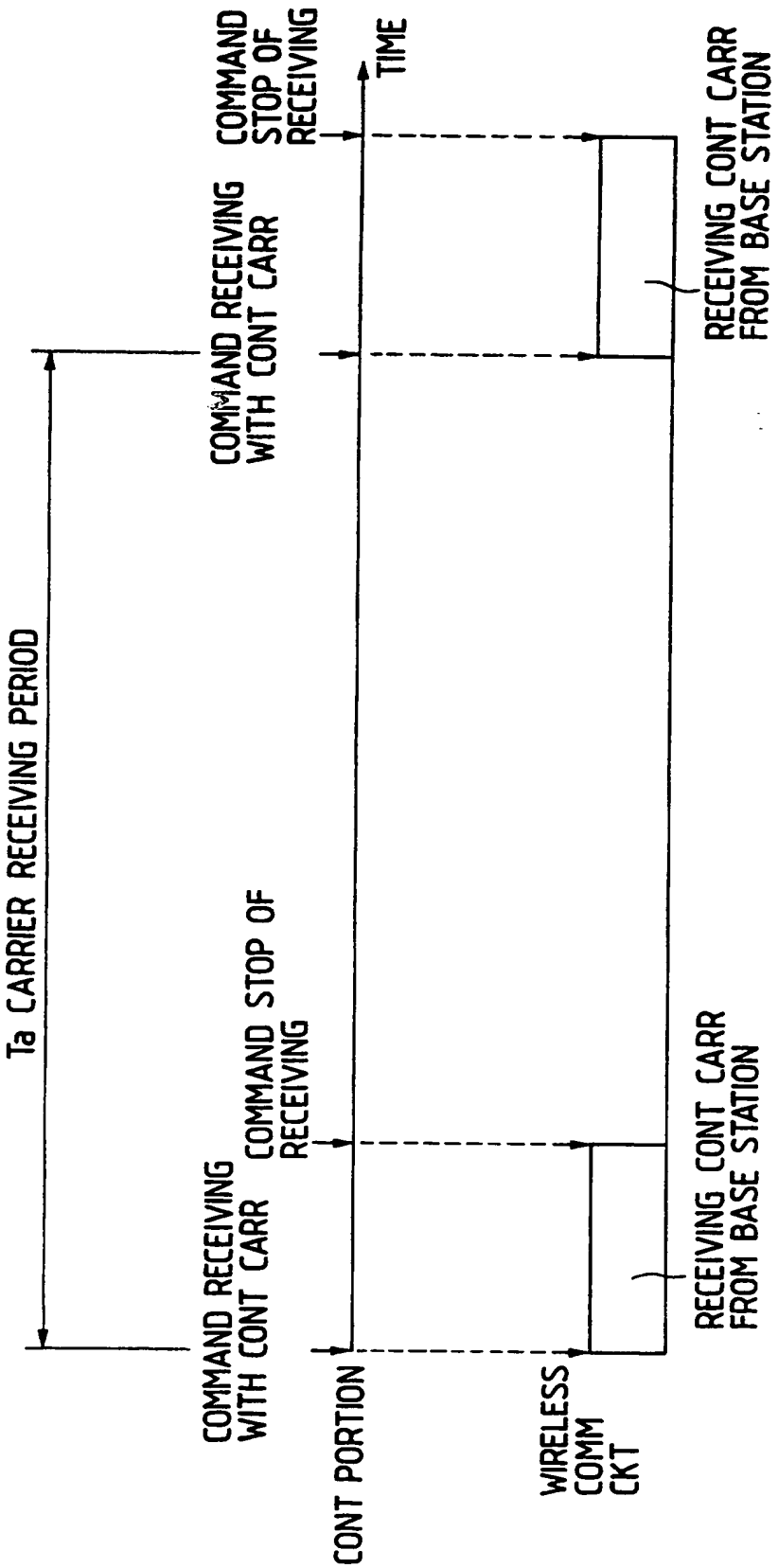

CONT PORTION
WIRELESS COMM CKT
COMMAND RECEIVING WITH CONT CARR
COMMAND STOP OF RECEIVING
RECEIVING CONT CARR FROM BASE STATION
Ta CARRIER RECEIVING PERIOD
COMMAND RECEIVING WITH CONT CARR
COMMAND STOP OF RECEIVING
RECEIVING CONT CARR FROM BASE STATION
TIME

FIG. 6A

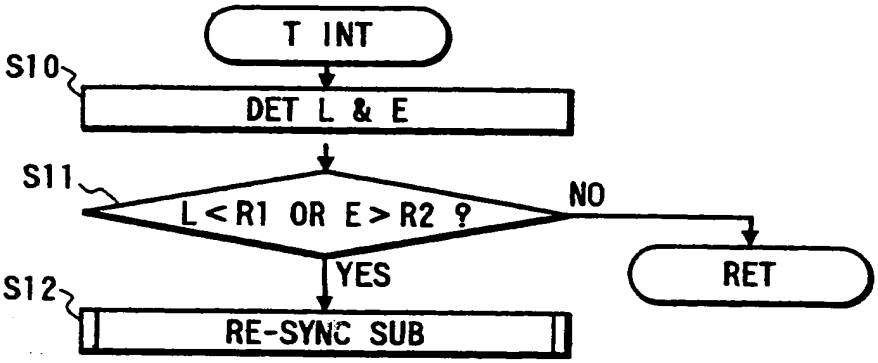

T INT
S10
DET L & E
S11
L<R1 OR E>R2 ?
NO
RET
YES
S12
RE-SYNC SUB

FIG. 6B

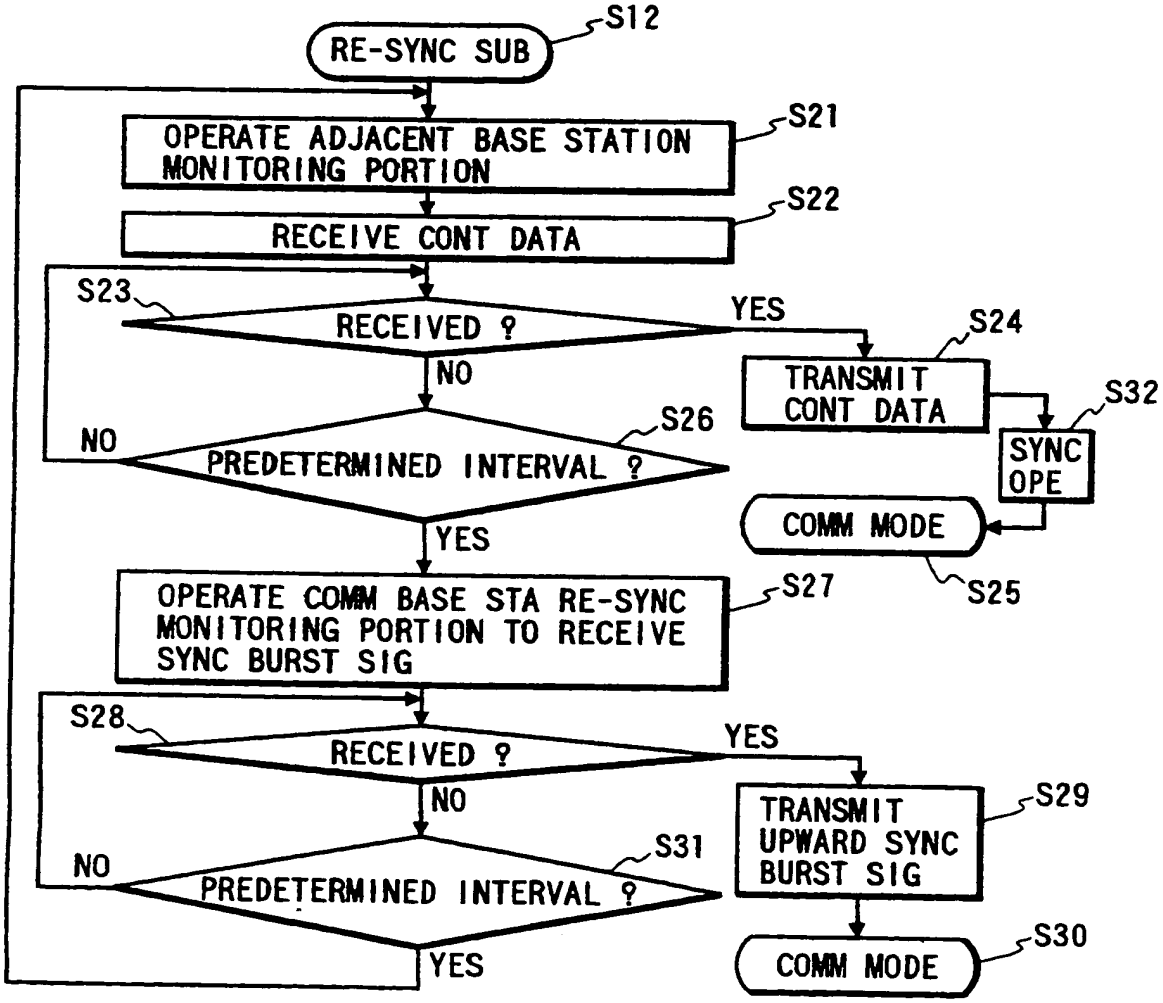

RE-SYNC SUB
S12
OPERATE ADJACENT BASE STATION MONITORING PORTION
S21
RECEIVE CONT DATA
S22
S23
RECEIVED ?
YES
S24
TRANSMIT CONT DATA
S32
SYNC OPE
NO
S26
NO
PREDETERMINED INTERVAL ?
YES
COMM MODE
S25
OPERATE COMM BASE STA RE-SYNC MONITORING PORTION TO RECEIVE SYNC BURST SIG
S27
S28
RECEIVED ?
YES
NO
TRANSMIT UPWARD SYNC BURST SIG
S29
S31
NO
PREDETERMINED INTERVAL ?
YES
COMM MODE
S30

FIG. 7

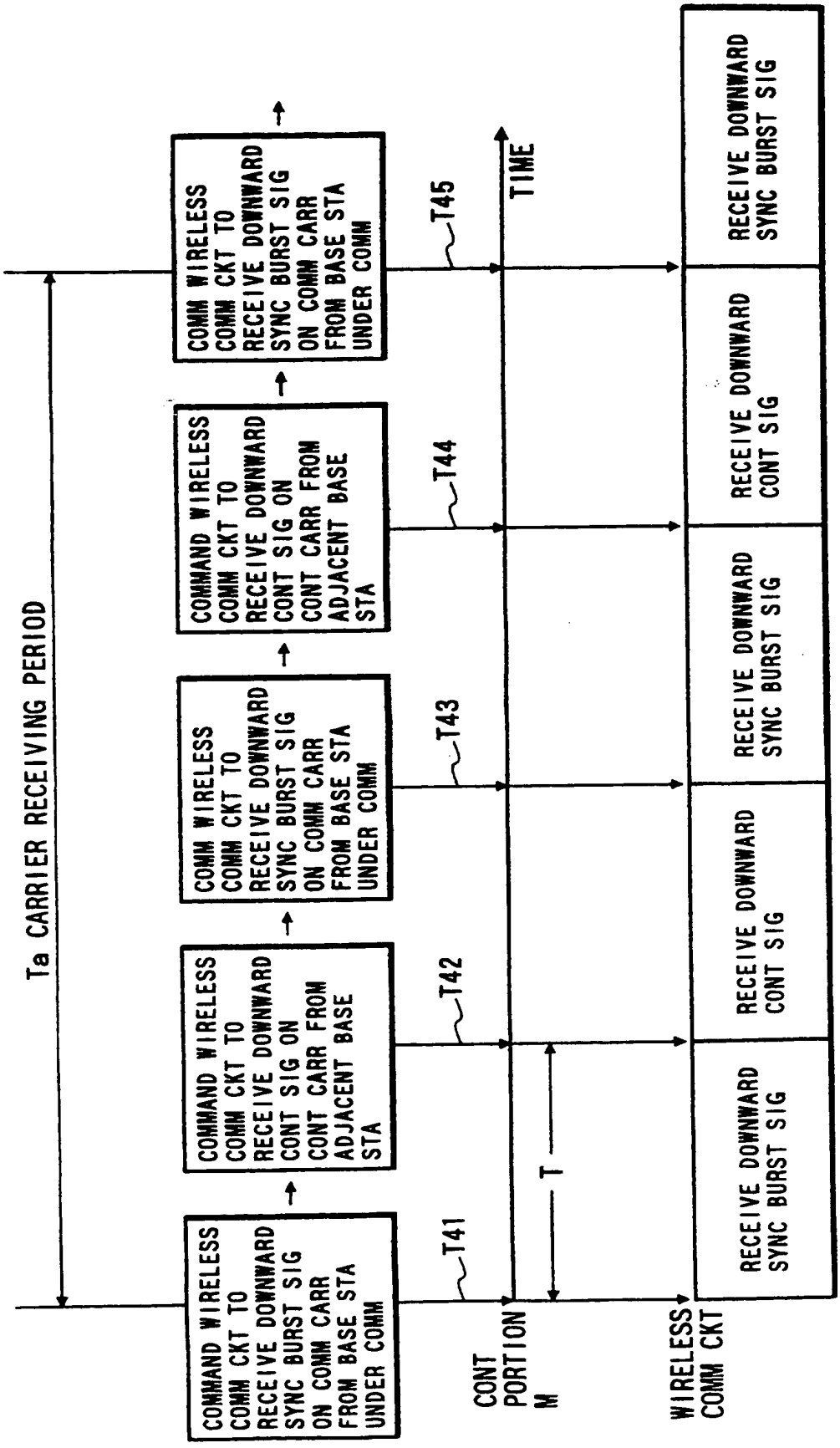

Ta CARRIER RECEIVING PERIOD
COMMAND WIRELESS COMM CKT TO RECEIVE DOWNWARD SYNC BURST SIG ON COMM CARR FROM BASE STA UNDER COMM
COMMAND WIRELESS COMM CKT TO RECEIVE DOWNWARD CONT SIG ON CONT CARR FROM ADJACENT BASE STA
COMM WIRELESS COMM CKT TO RECEIVE DOWNWARD SYNC BURST SIG ON COMM CARR FROM BASE STA UNDER COMM
COMMAND WIRELESS COMM CKT TO RECEIVE DOWNWARD CONT SIG ON CONT CARR FROM ADJACENT BASE STA
COMM WIRELESS COMM CKT TO RECEIVE DOWNWARD SYNC BURST SIG ON COMM CARR FROM BASE STA UNDER COMM
T41
T42
T43
T44
T45
T
TIME
CONT PORTION M
WIRELESS COMM CKT
RECEIVE DOWNWARD SYNC BURST SIG
RECEIVE DOWNWARD CONT SIG
RECEIVE DOWNWARD SYNC BURST SIG
RECEIVE DOWNWARD CONT SIG
RECEIVE DOWNWARD SYNC BURST SIG

FIG. 8

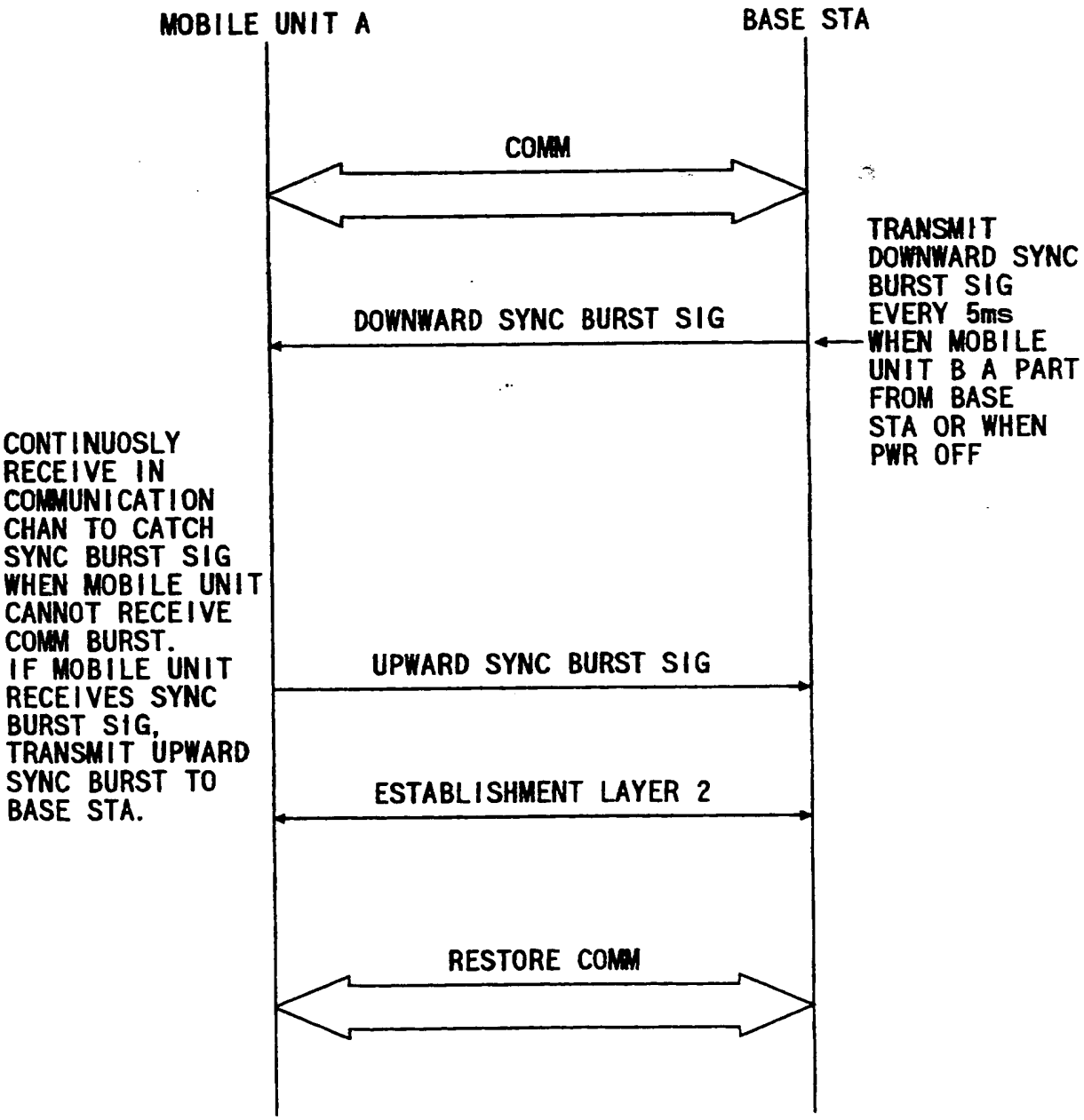
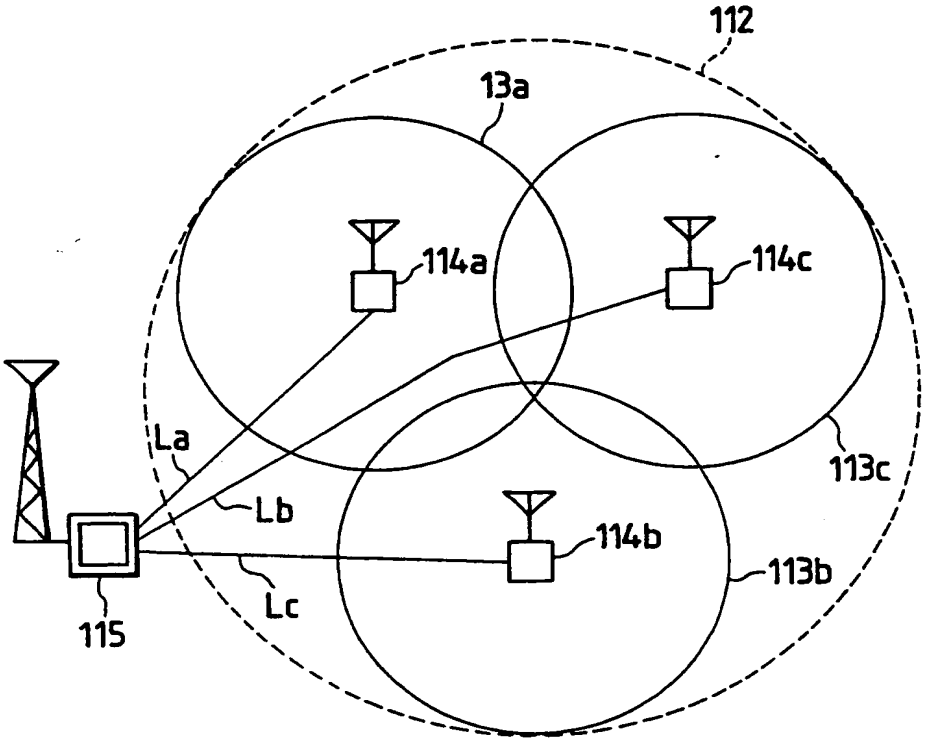

MOBILE UNIT A
BASE STA
COMM
TRANSMIT DOWNWARD SYNC BURST SIG EVERY 5ms WHEN MOBILE UNIT B A PART FROM BASE STA OR WHEN PWR OFF
DOWNWARD SYNC BURST SIG
CONTINUOSLY RECEIVE IN COMMUNICATION CHAN TO CATCH SYNC BURST SIG WHEN MOBILE UNIT CANNOT RECEIVE COMM BURST. IF MOBILE UNIT RECEIVES SYNC BURST SIG, TRANSMIT UPWARD SYNC BURST TO BASE STA.
UPWARD SYNC BURST SIG
ESTABLISHMENT LAYER 2
RESTORE COMM

FIG. 9
PRIOR ART



TITLE OF THE INVENTION

A MOBILE UNIT COMMUNICATION APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a mobile unit communication apparatus selectively communicating with at least first and second base stations to communicate with a network, the first and second base stations respectively having first and second service areas partially overlapping each other.

2. Description of the Prior Art

A mobile unit communication apparatus, comprising a communication circuit for selectively communicating with at least first and second base stations, coupled to the same network, respectively having first and second service areas, partially overlapping each other, through first and second radio wave signals is known. Such a prior art mobile unit communication apparatus is disclosed in U.S.P. Nos. 4,096,440 and U.S.P. 4,640,986.

A control system for mobile radio communication is disclosed in U.S.P. No. 4,096,440 as shown in Fig. 9, in which the whole service area 112 is composed of a plurality of small radio service zones 114a to 114c in each of which communication is sufficiently possible with the transmitting power of any of mobile stations belonging to

the service zone, a base station of each of the small radio service zones and a control station 115 for controlling the whole service area are intercommunicated through a binary coded transmission line, and in order to prevent simultaneous transmission of the control signal from a plurality of mobile stations when the mobile stations in the whole service area achieve transmission and reception of the control signal between each of them and the control station over a common control channel, the control station transmits to the mobile stations information representative of the busy or idle status of the common control channel from the mobile stations by the interruption and transmission of an idle line indication signal. By reversing the signal state of the binary coded transmission line to its normal state, information of the detection of transmission from the mobile stations by the base stations is transmitted to the control station, and in the control station, the idle channel indication signal is interrupted by the earliest one of the reversed signals arriving from the plurality of base stations. The start of the control signal is indicated by restoring the signal state of the binary code transmission line to its normal state. The control station resumes transmission of the idle channel indication signal upon completion of the reception of the control signal.

A mobile radio communication system disclosed in U.S.P. 4,640,986 has a plurality of fixed stations respectively connected to a plurality of subscriber's lines extending from a telephone exchange, and a plurality of mobile stations linked with the fixed stations through radio channels. Each of the mobile stations effects speech via one of the fixed stations. The system comprises a means provided for each fixed station for transmitting rate charging information from the telephone exchange to a mobile station under speech, and a rate collecting means provided for each mobile station and being responsive to the rate charging information to vary its content.

SUMMARY OF THE INVENTION

The aim of the present invention is to provide an improved mobile unit communication apparatus.

According to this invention, there is provided a first mobile unit communication apparatus, which comprises: a communication portion for communicating with a network via one of at least first and second base stations respectively having first and second service areas, partially overlapping each other, through first and second radio wave signals having TDMA/TDD formats; a first detection portion for detecting a condition of the first radio wave signal at the communication portion when the communication portion communicating with the first base

station; a comparing portion for comparing the condition with a reference; a first control portion for operating the communication portion to communicate with the second base station and effecting a first synchronizing operation with the second base station through the communication portion for a first predetermined interval; a second control portion for operating the communication portion to communicate with the first base station and effecting a second synchronizing operation with the first base station through the communication portion for a second predetermined interval; and a third control portion for alternately operating the first and second control portions in accordance with the result of the comparing portion until either of the first or second synchronizing operation is succeed to continue the communication which was established by the first base station via either of the first or second base station.

According to this invention, there is provided a second mobile unit communication apparatus which comprises: a communication portion for selectively communicating with at least first and second base stations, coupled to the same network, respectively having first and second service areas, partially overlapping each other, through first and second radio wave signals having TDMA/TDD formats, the first and second base stations further transmitting

downward synchronizing control signals; a receiving portion for receiving the downward synchronizing control signal from the second base station; a transmitting portion for transmitting an upward synchronizing control signal requesting communication with the second base station; a first detection portion for detecting a condition of first radio wave signal at the communication portion when the communication portion communicating with the first base station; a comparing portion for comparing the detected condition with a reference; a first control portion for operating the communication portion to effect a temporary stop of the communication with the first base station in accordance with the result of comparing by the comparing portion, the first base station further transmitting a downward synchronizing burst signal as the first radio wave signal when the first base station detects the temporary stop of the communication with the mobile unit communication apparatus; a first monitoring portion for monitoring and detecting the down synchronizing burst signal in the first radio wave signal using the communication portion for a first predetermined interval; a second monitoring portion for monitoring the downward synchronizing control signal for a second predetermined interval; a second control portion responsive to the comparing portion for effecting a first synchronizing

operation by operating the communication portion for communicating with the first base station when the first monitoring portion detects the down synchronizing burst signal and for effecting a second synchronizing operation by operating the transmitting portion for transmitting the upward synchronizing control signal to the second base station when the second monitoring portion detects the down synchronizing control signal.

In the second mobile unit communication apparatus, the control portion effects the first and second synchronizing operations alternately.

BRIEF DESCRIPTION OF THE DRAWINGS

The object and features of the present invention will become more readily apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

Fig. 1A is a block diagram of a mobile unit communication apparatus and a base station of an embodiment of this invention;

Fig. 1B is an illustration of this embodiment showing an arrangement of the mobile unit communication apparatus and base stations;

Fig. 2 is an illustration of this embodiment for illustrating a data transmission format;

Fig. 3 is an illustration of transmission data

formats of bursts of this embodiment;

Fig. 4 is a diagram of a flow chart of this embodiment showing the waiting operation;

Fig. 5 is a drawing of a timing chart of this embodiment showing an operation of the mobile unit communication apparatus on the intermittent receiving;

Figs. 6A and 6B are diagrams of flow charts of this embodiment;

Fig. 7 is a drawing of a timing chart of this embodiment showing the synchronizing operation;

Fig. 8 is an illustration of this embodiment showing a sequence of communication between the mobile unit communication apparatus and the base station for restoring the communication operation; and

Fig. 9 is an illustration of a prior art mobile communication system.

The same or corresponding elements or parts are designated with like references throughout the drawings.

DETAILED DESCRIPTION OF THE INVENTION

Hereinbelow will be described an embodiment of this invention.

Fig. 1A is a block diagram of a mobile unit communication apparatus of this embodiment. In Fig. 1A, reference A1 denotes a base station or a private branch base station and reference B denotes a mobile unit

communication apparatus (mobile unit). In the base station A1, numeral 1 denotes an antenna coupled to a wireless communication circuit 2. The wireless communication circuit 2 effects transmitting and receiving wireless communication data with a frequency and transmission and receiving timings controlled by a wireless communication control portion 3. Numeral 2a denotes a synthesizer included in the wireless communication circuit 2 for generating a frequency commanded by the wireless control portion 3. The wireless communication control portion 3 measures a receiving level of a received wireless communication data and judges a position of the mobile unit communication apparatus B and stores it in a temporary memory 4. Numeral 5 is a communication/line control portion which is connected to a line 6 or a network NET and to a channel codec portion 7. Numeral 8 denotes a control portion including a microprocessor or the like for supplying a line control command to the communication/line control portion 5. The communication/line control portion 5 converts the sound signal received from the line 6 into a digital signal and transfers it to the channel codec portion 7 and analog-to- digital-converts the sound signal from the line 6 and digital-to-analog-converts a digital sound data received from the channel codec portion 7 and transmits it to the line 6. The channel codec portion 7

assembles and decomposes data transmitted and received through a wireless communication channel and a wireless communication control channel. The data in the communication channel includes data of sounds or the like and control data generated by the control portion 8, wherein user data such as the sound data is processed with the control portion 8 bypassed. In the control portion 8 of the base station A1, reference 8a denotes a communication condition storing portion for storing the frequency and the time slot used during communication with the mobile unit communication apparatus B and for transmitting a synchronizing burst signal to the mobile unit communication apparatus B when a signal from the mobile unit communication apparatus B cannot be received during communication. Reference 8b denotes a synchronizing control portion for restoring the communication condition with the mobile unit communication apparatus B when a synchronizing control signal is received from the mobile unit communication apparatus B during transmitting the synchronizing burst signal to the mobile unit communication apparatus B.

When the channel codec portion 7 receives data through the control channel and control data through the communication channel from the antenna 1 via the wireless communication portion 2, the channel codec portion 7

transfers only data to the temporary memory 4 to inform the control portion 8 of an arrival of a call. The channel codec portion 7 informs the wireless communication control portion 3 and the wireless communication circuit 2 of each receiving timing. The receiving frequency is set to the wireless communication control portion 3 in advance by the control portion 8 at respect receiving timings. If the control data is transmitted, the control portion 8 informs the wireless communication control portion 3 and the wireless communication circuit 2 of the transmission timings and then transmits the data to the wireless communication circuit 2. Moreover, the channel codec portion 7 has functions for generating transmission timings of control data periodically and intermittently transmitted in the control channel, detecting the presence or absence of errors during the data receiving, and transferring it to the temporary memory 4 together with the received data.

In the mobile unit communication apparatus B, numeral 10 denotes an antenna connected to a wireless communication circuit 11. The wireless communication circuit 11 includes a synthesizer 11a. Numeral 12 denotes a wireless communication control portion, numeral 13 denotes a channel codec portion, numeral 14 denotes a control portion including a microprocessor effecting functions of an adjacent base station monitoring portion

14a, a communicating base station re-synchronizing monitoring portion 14b, and a monitor control portion 14c. Numeral 15 denotes a temporary memory. Respective portions mentioned above have basically similar functions to the base station A. However, the mobile unit communication apparatus B does not effect an intermittent transmission function, so that the channel codec portion 13 does not have a timing generation function of the intermittent transmission of control data through the control channel. Instead of this, the channel codec portion 13 has a timing generation function for, during waiting a call, intermittently receiving a signal on the control channel intermittently transmitted from the base station to suppress a mean consumption current of the internal battery (not shown) of the mobile unit communication apparatus B and a function for generating a transmission timing on the basis the receiving timing of the signal from the base station. Numeral 16 denotes a communication control portion, numeral 17 is a receiver, and numeral 18 denotes a microphone. The communication control portion 16 effects an analog-digital conversion between the channel codec portion 13 and the receiver 17 and microphone 18. An operation portion 19 and a display portion 20 are connected to the control portion 14. The control portion 14 detects a start of communication from the operation portion 19 or

outputs data for displaying to the display portion 20.

Fig. 1B is an illustration of this embodiment showing an arrangement of the mobile unit communication apparatus B and the base stations A1 and A2. The mobile unit communication apparatus B selectively communicating with the base station A1 and the base station A2 to communicate with the network NET. The base stations SA1 and SA2 respectively have first and second service areas SA1 and SA2 partially overlapping each other. Therefore, at a common service area CA, the mobile unit communication apparatus B can communicate with either of base stations A1 and A2. However, distances from the mobile unit communication apparatus B to the base station A1 and the base station A2 are large, so that there may be a difficulty in communication with either of these base stations A1 and A2 to some degree as a circumference condition around the mobile unit communication apparatus B. Then, it is necessary to selectively communicate with either of the base stations A1 or A2 as the receiving condition of the mobile unit communication apparatus demands.

The communication between the base station A1 and the mobile unit communication apparatus B and the communication between the base station A2 and the mobile unit communication apparatus B are independently provided

by frequency division multiple access manner (FDMA) both in the communication channel and the control channel.

Then, the TDMA/TDD (time division multiple access/time division duplex) method providing a bidirectional transmission, that is, a plurality of upward and downward transmission paths will be briefly described.

Fig. 2 is an illustration of this embodiment for illustrating a data transmission format. A frequency carrier is divided into upward (the direction from a mobile unit communication apparatus B to the base station A1 or from a mobile unit communication apparatus on an arrival side to another mobile unit communication apparatus on a call side) blocks and downward (the direction from the base station A to a mobile unit communication apparatus B or from a mobile unit communication apparatus on the transmission side to anther mobile unit communication apparatus on an arrival side) blocks. The upward block and down ward block are generated alternately to provided the time division duplex (TDD), that is, bidirectional communication between the base station and mobile unit communication apparatus. Each of the upward blocks includes upward communication slots TS1 to TS4 to provide the time division multiple access (TDMA), that is, communications between the base station and each of mobile unit communication apparatus under communication are

independently provided, wherein each of upward communication time slots, for example TS3, and the corresponding time slot TS3' provide a bidirectional communication between one of mobile unit communication apparatus B and the base station A1. That is, a pair of upward and downward time slots provided one bidirectional channel.

In a communication between the base station A1 and a mobile unit communication apparatus B, a carrier for control for transmitting control data for connection control and a carrier for communication for transmitting sound or user's data have different frequencies and independently used. Generally, channels provided by the carrier for communication is referred as a communication channel and channels provided by the carriers for control are referred as a control channel.

The communication between the base station A1 and the mobile unit communication apparatus B and the communication between the base station A2 and the mobile unit communication apparatus B are independently provided by frequency division multiple access manner (FDMA) both in the communication channel and the control channel.

Fig. 3 is an illustration of transmission data formats of bursts of this embodiment. In the communication channel, communication data burst including user data such

as sound data and a synchronizing burst including a fixed data pattern for synchronizing are transmitted, wherein the burst means that a data block transmitted for an interval of one slot. In the control channel, a control data burst including control data is transmitted.

In the case of a communication between the base station 1A and a mobile unit communication apparatus B, in the downward control channel, control data is transmitted solely and then, no signal is transmitted in the downward control channel for a predetermined interval and this cycle is repeated. That is, the control data is intermittently transmitted with the predetermined no signal transmission period. This is referred as an intermittent transmission for periodically transmitting necessary data to provided an immediate access to the base station 1A by a mobile unit communication apparatus B entering the service area SA1 of the base station 1A. Moreover, an arrival of a call at a mobile unit communication apparatus B is informed using this intermittent transmission. The upward signal on the control channel is used in the case that a mobile unit communication apparatus B requests a base station to assign a communication channel for making a call, so that it is transmitted in a random access manner but transmitted for an interval of upward transmission. In the case that the base station A1 assigns the communication channel to the

mobile unit communication apparatus B, a downward control signal is transmitted by the intermittent transmission also. Once the communication channel is assigned, the mobile unit communication apparatus B continuously transmits a synchronizing burst signal to the base station A1 in the communication channel. The mobile unit communication apparatus B and the base station 1A recognize to acquire one to one bidirectional communication channel by the continuously transmitting the synchronizing burst signal and it is possible to transmit burst signals for communication each other through the successive communication data burst. The synchronizing burst signal includes a long preamble (PR) and a long unique word (UW) to surely provide synchronizing because the synchronizing burst signal is firstly continuously transmitted after the communication moves to the communication mode using the communication channel. The communication burst has a short preamble and short unique word because it is continuously transmitted. Instead of this, a user's data field for storing sound or user's data is sufficiently long.

Then, a waiting operation of the mobile unit communication apparatus B will be described. Fig. 4 is a diagram of a flow chart of this embodiment showing the waiting operation.

On waiting for communication between the base

station A1 and the mobile unit communication apparatus B, in response to a start up by turning a power on of the mobile unit communication apparatus B or the like, the control portion 14 in the mobile unit communication apparatus B commands the channel codec portion 13 to enter a continuously receiving condition to wait for reception of the downward control signal intermittently transmitted in the control channel from the base station A1 in steps 131 and 139. Then, when the downward control signal from the base station is received, the control portion 14 judges whether or not the received signal is that from the base station to be coupled to the mobile unit communication apparatus B. That is, the base station A1 and the mobile unit communication apparatus B are registered in advance to judge whether the mobile unit communication apparatus B can be coupled to the base station with reference to data of the registration. If the signal from the base station A1 to be coupled, communication with the base station A1 is executed each other to register the position of the mobile unit communication apparatus B as necessary. Then, the control portion 14 commands the channel codec portion 13 to intermittently receive the arrival signal from the base station A1 in phase with the timing of the intermittent transmission in steps 132, 133, 134, 140, 141, 142, and 143. If the arrival data is received, the control portion 14

commands the channel codec portion 13 to transmit the control data in steps 135, 136, 137, 138, 144, 145, 146, and 147 and processing moves to the connection operation in step 138.

Fig. 5 is a drawing of a timing chart of this embodiment showing an operation of the mobile unit communication apparatus B on the intermittent receiving. In Fig. 5, reference Ta represents a carrier receiving period matched to the timings of the intermittent transmission from the base station A1 and the intermittent receiving is effected at these timings. Moreover, in the intermittent receiving, it is desired that a receiving-power-on interval matches to the actual data receiving interval infinitely. However, in consideration of a start up interval of the wireless communication circuit in response to a power on, it is general to start up and operates the wireless communication circuit 11 to receive the carrier earlier than the actual data receiving interval.

A call from the base station A1 or a call from the mobile unit communication apparatus B are provided through the control channel and the data or sound data communication and the synchronizing burst signal are transmitted through the communication channel. Therefore, each of mobile unit communication apparatus in the service

area SA1 of the base station A1 can communicate with the line 6 as desired or as necessary.

Then, an operation in the case that a level of the transmission signal received by the mobile unit communication apparatus decreases will be described.

Figs. 6A and 6B are diagrams of flow charts of this embodiment. The control portion 14 executes a timer interruption operation shown in Fig. 2A in response to a timer 14 included therein. In step s10, the control portion 14 detects a level L of the received signal from the base station A at the wireless communication circuit 11 and a frame error rate E in the communication burst for a predetermined period from the wireless communication circuit 11. The control portion 14 makes a decision as to whether the level L of the received signal from the base station A at the wireless communication circuit 11 is less than a reference R1 or the frame error rate E in the communication burst for the predetermined period is larger than a reference R2 in step s11, that is, the control portion compares the level L with the reference. If the level L of the received signal from the base station A at the wireless communication circuit 11 is less than a reference R1 or the frame error rate E in the communication burst for the predetermined period is larger than a reference R2, processing proceeds to a re-synchronizing

subroutine s12. If the level L of the received signal from the base station A at the wireless communication circuit 11 is not less than a reference R1 or the frame error rate E in the communication burst for the predetermined period is not larger than a reference R2, processing returns to the original step which was executed before this time interruption, that is, one step of a communication processing for example.

In the re-synchronizing subroutine s12, at first, the control portion 14 operates the adjacent base station monitoring portion 14a as a function of the monitor control portion 14c, that is, the wireless communication portion 11 is operated to change the carrier frequency of the control channel to the carrier frequency of the control channel of the adjacent base station A2, that is, change the carrier frequency to the carrier frequency of the control channel other than the base station A1 but an adjacent base station A2.

In the following step s22, the control portion 14 waits to receive the control data from the adjacent base station A2 through the control channel. If the control portion 14 receives the control data from the adjacent base station A2 within a predetermined interval in step s23, the control portion 14 transmits control data using the channel codec portion 13 and the wireless communication portion 11

to establish a communication with the adjacent base station A1 to provided continuation of the call to the line 6 which was made by the base station A1 through execution of a predetermined connection operation.

In step s26, if the control portion does not receive the control data from the adjacent base station A2 within the predetermined interval, the control portion 14 judges that there is no adjacent base station around the mobile unit communication apparatus B and operates the communication base station re-synchronizing monitoring portion 14b to, using the wireless communication circuit 11 and the channel codec portion 13, receive the synchronizing burst signal from the base station with which the mobile unit communication apparatus communicated. In the following step s28, if the control portion 14 receives the downward synchronizing burst signal with in the predetermined interval which is generally equal the predetermined interval in step s26 but may be different as necessary, processing proceeds to step s29. In step s29, the control portion 14 receiving the downward synchronizing burst signal transmits the upward synchronizing burst signal. Then, the base station A1 receiving the upward synchronizing burst signal and the mobile unit communication apparatus B transmitting the upward synchronizing burst signal enter the communication mode

again. That is, the control portion 14 sets the slot and the frequency for transmitting and receiving sound data or the like by reading the data from the temporary memory 15 and executes the communication operation and sets the timer interruption shown in Fig. 2A again.

In step s31 if the control portion 14 does not receive the downward synchronizing burst signal within the predetermined interval, processing returns to step s21 to catch the adjacent base station A2 through a first processing including steps s21, s22, s23, and s26 and a second processing including step s27, s28, and s31. These first and second processings are alternately repeated until either of an adjacent base station or the base station with which the mobile unit communication apparatus communicated is caught to continue the communication with the line 6 as the function of the monitor control portion 14c.

In this operation, the control portion 14 receives the synchronizing control signal from the adjacent base station A2 at first. However, it is also possible to receive the synchronizing bust signal from the base station A1 at first.

Fig. 7 is a drawing of a timing chart of this embodiment showing the synchronizing operation in the case that the mobile unit communication apparatus B receives neither of the control signal from the adjacent base

station and the downward synchronizing burst signal from the base station under communication. At a timing T41, the control portion 14 commands wireless communication circuit 11 to receive the downward synchronizing burst signal on the communication carrier from the base station under communication. Then, the wireless communication circuit 11 operates to receive the downward synchronizing burst signal. At the following timing T42 after a predetermined interval T, the control portion 14 commands the wireless communication circuit to receive the downward control signal on the control carrier from the adjacent base station A2. In response, the wireless communication circuit 11 operates to receive the downward control signal on the control carrier from the adjacent base station A2. However, the mobile unit communication apparatus B is failed in receiving neither of the downward synchronizing burst signal on the communication carrier from the base station under communication and the downward control signal on the control carrier from the adjacent base station A2 Then, these operations are alternately repeated at the timings T43 and T44 with the carrier receiving period and these operations repeated at the following carrier receiving period Ta such as a timing T45, wherein the control portion 14 detects the decrease in the level L at the previous carrier receiving period Ta.

Fig. 8 is an illustration of this embodiment showing a sequence of communication between the mobile unit communication apparatus B and the base station A1 for restoring the communication operation, wherein the operation of receiving the downward synchronizing control signal from the base station A2 and transmitting the upward synchronizing control signal are omitted.

The communication condition storing portion 14d stores the communication condition with the base station A1 and the frequency and the time slot used for the communication. While the communication the control portion detects the decrease in the level L of the received signal, the communication condition storing portion 14 stores this condition.

On the other hand, the base station A1 stores the frequency and the time slot used for communication with the mobile unit communication apparatus B in the communication condition storing portion 8a. When the base station detects that it cannot receive the signal from the mobile unit communication apparatus B, the control portion 14 transmits the synchronizing burst signal through the time slot determined by the data of the time slot used to the mobile unit communication apparatus B every 5 ms using the temporary memory 4, the channel codec portion 7, and the wireless communication portion 2 via the antenna 1.

When the level L of the received signal at the mobile unit communication apparatus B returns to the normal, that is, when the level L is not smaller than the reference R1, the control portion 14 of the mobile unit communication apparatus B confirms that a sound communication or a data communication was being effected during the interruption of the communication due to the decrease in the level L of the received signal by reading data in the temporary memory 15. Then, the control portion 14 sets the temporary memory 15 to use the frequency and the time slot, which were used for the communication, again. Then, the control portion 14 commands the channel codec portion 13 to effect the continuos receiving to monitor the downward synchronizing burst signal from the base station A1. When the mobile unit communication apparatus B receives the downward synchronizing burst signal from the base station A1 through the antenna 10, the wireless communication circuit 11, the channel codec portion 13, and the temporary memory 15 within the predetermined interval, the communicating base station re-synchronizing monitoring portion 14b commands the temporary memory 15 and the channel codec portion 13 to transmit the upward synchronizing burst signal to the base station A1 and then, the mobile unit communication apparatus B returns to the sound or data communication condition again. If the mobile unit communication

apparatus B does not receive the down synchronizing burst signal within the predetermined interval, the mobile unit communication apparatus B enters a waiting condition. On the other hand, when the base station A1 receives the upward synchronizing burst signals from the mobile unit communication apparatus B, the control portion 8 of the base station A1 returns to the sound or data communication condition with the mobile unit communication apparatus B, so that the sound or data communication is provided again.

The communication condition storing portion 8a and the synchronizing control portion 8b in the control portion 8 in the base station A1 and the communication condition storing portion 14d and the synchronizing control portion 14c in the control portion 14 of the mobile unit communication apparatus B store the frequency and the slot used for the communication when the communication was started, so that the synchronized operation with the base station A1 with which the mobile unit communication apparatus B has communicated is immediately provided and the communication is started again immediately.

As mentioned the mobile unit communication apparatus B, comprises: the wireless communication portion 11 for via communicating with a network, i.e., the line 6, via one of at least first and second base stations A1 and A2 respectively having first and second service areas SA1 and

SA2, partially overlapping each other, through first and second radio wave signals having TDMA/TDD formats TS1-TS4 and TS1'-TS4'; a first detection processing step s10 for detecting a condition of first radio wave signal at the wireless communication portion 11 when the wireless communication portion 11 communicating with the first base station A1; a comparing processing s11 for comparing the condition with a predetermined condition R1 or R2; the adjacent base station monitoring portion 14a for operating the wireless communication portion 11 to communicate with the second base station A2 and effecting a first synchronizing operation st32 with the second base station A2 through the wireless communication portion 11 for a predetermined interval; the communicating base station re-synchronizing monitoring portion 14b for operating the wireless communication portion 11 to communicate with the first base station A1 and effecting a second synchronizing operation s29 with the first base station through the wireless communication portion 11; and the monitor controlling portion 14c for alternately operating the adjacent base station monitoring portion 14a and the communication base station re-synchronizing portion 14b in accordance with the result of comparing by said comparing portion until either of the first or second synchronizing operation is succeed to continue the communication with the

line 6 which was established by the first base station A1 via either of the first or second base station.

In other words, the mobile unit communication apparatus, comprises the wireless communication portion 11 for selectively communicating with at least base stations A1 and A2, coupled to the same network NET, respectively having first and second service areas SA1 and SA2, partially overlapping each other, through first and second radio wave signals RW1 and RW2 having TDMA/TDD formats; a receiving portion including the wireless communication circuit 11, wireless communication control portion 12, channel codec portion 13, and the temporary memory 15 for receiving the downward synchronizing control signal from the second base station A2; a transmitting portion including the wireless communication circuit 11, the wireless communication control portion 12, the channel codec portion 13, and the temporary memory 15 for transmitting the upward synchronizing control signal requesting communication with the second base station A2; a first detection portion effected by the control portion 14, the wireless communication circuit 11, and the channel codec portion 13 for detecting a condition of first radio wave signal RW1 from the base station A1 when the wireless communication circuit 11 communicating with the first base station A1; a comparing portion for comparing the condition

with a reference R1 or R2; the control portion 14 for operating the wireless communication circuit 11 to effecting a temporary stop of the communication with the first base station A1 in accordance with the result of said comparing portion, the first base station A1 further transmitting a downward synchronizing burst signal as the first radio wave signal RW1 when the first base station A1 detects the temporary stop of the communication with the first base station A1; a communicating base station re-synchronizing monitoring portion 14b for monitoring and detecting the down synchronizing bust signal using the wireless communication circuit 11 for the first predetermined interval; the adjacent base station monitoring portion 14a for monitoring the downward synchronizing control signal for the second predetermined interval; the monitor control portion 14c for effecting a first synchronizing operation by operating the wireless communication circuit 11 for communicating with the first base station A1 when the communication base station re-synchronizing monitoring portion 14b detects the down synchronizing burst signal and for effecting a second synchronizing operation by operating the transmitting portion for transmitting the upward synchronizing control signal to the second base station A2 when the adjacent base station monitoring portion 14a detects the down

synchronizing control signal, the monitoring control portion effecting the first and second synchronizing operations alternately in accordance with the result of the comparing portion.

CLAIMS

1. A mobile unit communication apparatus, comprising:

communication means for communicating with a network via one of at least first and second base stations respectively having first and second service areas, partially overlapping each other, through first and second radio wave signals having TDMA/TDD formats;

first detection means for detecting a condition of said first radio wave signal at said communication means when said communication means communicating with said first base station;

comparing means for comparing said condition with a predetermined condition;

first control means for operating said communication means to communicate with said second base station and effecting a first synchronizing operation with said second base station through said communication means for a first predetermined interval;

second control means for operating said communication means to communicate with said first base station and effecting a second synchronizing operation with said first base station through said communication means for a second predetermined interval; and

third control means for alternately operating said

first and second control means in accordance with the result of said comparing means until either of said first or second synchronizing operation is succeed to continue the communication which was established by said first base station via either of said first or second base station.

2. A mobile unit communication apparatus, comprising:

communication means for selectively communicating with at least first and second base stations, coupled to the same network, respectively having first and second service areas, partially overlapping each other, through first and second radio wave signals having TDMA/TDD formats, said first and second base stations further transmitting downward synchronizing control signals;

receiving means for receiving said downward synchronizing control signal from said second base station;

transmitting means for transmitting an upward synchronizing control signal requesting communication with said second base station;

first detection means for detecting a condition of first radio wave signal at said communication means when said communication means communicating with said first base station;

comparing means for comparing said condition with a reference;

first control means for operating said communication means to effect a temporary stop of said communication with said first base station in accordance with the result of comparing by said comparing means, said first base station further transmitting a downward synchronizing burst signal as said first radio wave signal when said first base station detects said temporary stop of said communication with said mobile unit communication apparatus;

first monitoring means for monitoring and detecting said down synchronizing burst signal in said first radio wave signal using said communication means for a first predetermined interval;

second monitoring means for monitoring said downward synchronizing control signal for a second predetermined interval; and

second control means responsive to said comparing means for effecting a first synchronizing operation by operating said communication means for communicating with said first base station when said first monitoring means detects said down synchronizing burst signal and for effecting a second synchronizing operation by operating said transmitting means for transmitting said upward synchronizing control signal to said second base station when said second monitoring means detects said down synchronizing control signal.

3. A mobile unit communication apparatus as claimed in claim 2, wherein said control means effects said first and second synchronizing operations alternately.

4. A mobile unit communication apparatus constructed and arranged substantially as hereinbefore described with reference to and as illustrated in Figures 1 to 8 of the accompanying drawings.

The Patent Office

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Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H4L LDSH, LDSX, LECX.

Int Cl (Ed.6): H04B 7/212, 7/26; H04Q 7/32, 7/38.

Other: ONLINE : WPI.

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	EP0577322A1	(NOKIA) - column 7 lines 3-29	1
X	EP0439630A1	(NIPPON TELEGRAPH) - Fig.9; column 11 line 6 to column 13 line 37	1
X	US5345467	(INTERDIGITAL) - column 8 lines 50-59, column 18 lines 54-64, column 19 line 47 to column 20 line 17	1

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.